

EXHIBIT K

MAAP-011248-DIE



Power Amplifier, 1 W DC - 22 GHz

Rev. V4

Features

- High Gain: 14 dB @ 12 V
- P1dB: 28 dBm @ 12 V
- P3dB: 30.5 dBm @ 12 V
- Output IP3: +38 dBm @ 12 V
- Supply Voltage: $V_{DD} = 9 - 12$ V
- Supply Current: $I_{DSQ} = 400$ mA
- 50 Ω Matched Input / Output
- Temperature Compensated Output Power Detector
- Die Size: 2.99 x 1.5 x 0.1 mm
- RoHS* Compliant

Description

The MAAP-011248-DIE is a 1 W distributed power amplifier offered as a bare die part. Operating from DC to 22 GHz, this power amplifier provides 14 dB of linear gain and 30.5 dBm of output power at 3-dB compression. The device is fully matched across the band and includes a temperature compensated output power detector.

The MAAP-011248-DIE can be used as a power amplifier stage or as a driver stage in higher power applications. This device is ideally suited for test and measurement, EW, ECM, and radar applications.

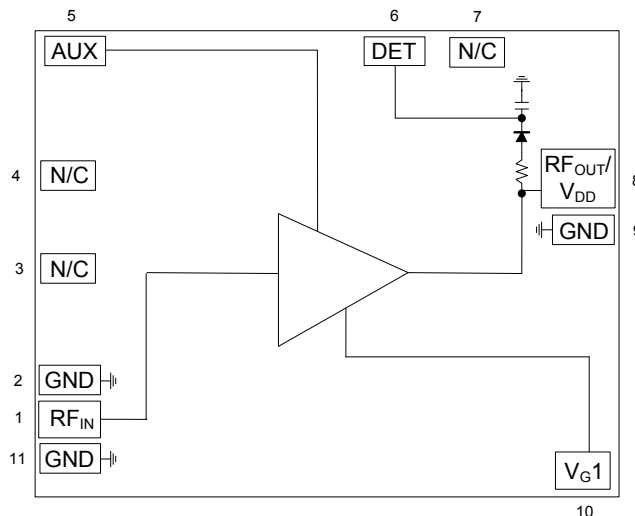
This product is fabricated using a GaAs pHEMT process which features full passivation for enhanced reliability.

Ordering Information

Part Number	Package
MAAP-011248-DIE	Gel Pack ¹

1. Die quantity varies.

Functional Schematic



Pin Configuration²

Pin No.	Pin Name	Description
1	RF _{IN}	RF Input
2	GND	Ground
3, 4	N/C	No Connection
5	AUX	Auxiliary
6	DET	Power Detector
7	N/C	No Connection
8	RF _{OUT} /V _{DD}	RF Output / Drain Voltage
9	GND	Ground
10	V _{G1}	Gate Voltage
11	GND	Ground

2. Backside of die must be connected to RF, DC and thermal ground.

*Restrictions on Hazardous Substances, European Union Directive 2011/65/EU.

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Electrical Specifications: $T_A = +25^\circ\text{C}$, $V_{DD} = 12\text{ V}$, $I_{DSQ}^3 = 400\text{ mA}$, $Z_0 = 50\ \Omega$

Parameter	Test Conditions	Units	Min.	Typ.	Max.
Gain	2 GHz 12 GHz 18 GHz 22 GHz	dB	— 11.5 — 11.5	13.0 13.5 14.0 14.5	—
P_{OUT}	$P_{IN} = +20\text{ dBm}$ 2 GHz 12 GHz 18 GHz 22 GHz	dBm	— 29.5 — 29.0	32.0 30.9 30.5 30.5	—
P1dB	2 GHz 12 GHz 18 GHz 22 GHz	dBm	—	30.5 29.0 28.0 27.5	—
OIP3	$P_{OUT} = +14\text{ dBm/tone}$ (10 MHz Tone Spacing) 2 GHz 12 GHz 18 GHz 22 GHz	dBm	—	41.0 38.0 38.0 41.0	—
PAE	$P_{IN} = +20\text{ dBm}$ 2 GHz 12 GHz 18 GHz 22 GHz	%	—	20.0 18.0 17.5 13.4	—
Input Return Loss	$P_{IN} = -20\text{ dBm}$	dB	—	15	—
Output Return Loss	$P_{IN} = -20\text{ dBm}$	dB	—	15	—
I_{DD} (with RF drive)	$P_{IN} = +20\text{ dBm}$	mA	—	500	—
I_{G1}	—	mA	—	8	—

3. Set I_{DSQ} according to bias procedures in page 4.

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Electrical Specifications: $T_A = +25^\circ\text{C}$, $V_{DD} = 10\text{ V}$, $I_{DSQ}^3 = 400\text{ mA}$, $Z_0 = 50\ \Omega$

Parameter	Test Conditions	Units	Min.	Typ.	Max.
Gain	2 GHz 12 GHz 18 GHz 22 GHz	dB	—	13.0 13.5 14.0 14.5	—
P_{OUT}	$P_{IN} = +18\text{ dBm}$ 2 GHz 12 GHz 18 GHz 22 GHz	dBm	—	29.0 29.0 29.0 28.0	—
P1dB	2 GHz 12 GHz 18 GHz 22 GHz	dBm	—	28.0 28.0 26.5 25.5	—
OIP3	$P_{OUT} = +14\text{ dBm/ton}$ e (10 MHz Tone Spacing) 2 GHz 12 GHz 18 GHz 22 GHz	dBm	—	45.0 41.5 47.0 40.0	—
PAE	$P_{IN} = +18\text{ dBm}$ 2 GHz 12 GHz 18 GHz 22 GHz	%	—	18.5 17.0 16.0 12.5	—
Input Return Loss	$P_{IN} = -20\text{ dBm}$	dB	—	15	—
Output Return Loss	$P_{IN} = -20\text{ dBm}$	dB	—	15	—
I_{DD} (with RF drive)	$P_{IN} = +18\text{ dBm}$	mA	—	450	—
I_{G1}	—	mA	—	8	—

Maximum Operating Ratings

Parameter	Rating
Input Power	20 dBm ($V_{DD} = 12\text{ V}$) 18 dBm ($V_{DD} = 10\text{ V}$)
Junction Temperature ^{4,5}	+150°C
Operating Temperature	-40°C to +85°C

4. Operating at nominal conditions with junction temperature $\leq +150^\circ\text{C}$ will ensure MTTF $> 1 \times 10^6$ hours.
5. Junction Temperature (T_J) = $T_C + \Theta_{JC} * ((V * I) - (P_{OUT} - P_{IN}))$
Typical thermal resistance (Θ_{JC}) = 6.5°C/W.
a) For $T_C = +85^\circ\text{C}$,
 $T_J = +117^\circ\text{C}$ @ 12 V, 0.48 A, $P_{OUT} = 30\text{ dBm}$, $P_{IN} = 20\text{ dBm}$

Absolute Maximum Ratings^{6,7}

Parameter	Absolute Maximum
Input Power	28 dBm
Drain Voltage	+16 V
Gate Voltage	-5 to 0 V
Junction Temperature ⁸	+175°C
Storage Temperature	-65°C to +125°C

6. Exceeding any one or combination of these limits may cause permanent damage to this device.
7. MACOM does not recommend sustained operation near these survivability limits.
8. Junction temperature directly effects device MTTF. Junction temperature should be kept as low as possible to maximize lifetime.

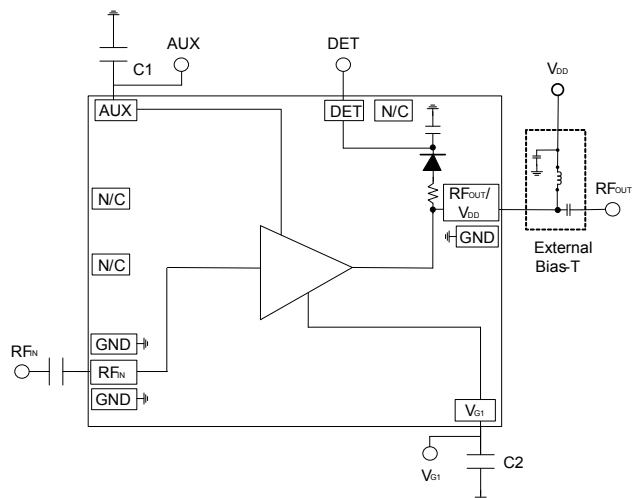
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Application Schematic



Bill of Materials^{9,10,11}

Part	Value	Size	Comment
C1, C2	1 μ F	0402	bypass

9. C1 & C2 are required for operation below 1 GHz.
 10. High power external bias tee was used for measurements.
 11. External DC block was used on input.

Biasing Conditions

Recommended biasing conditions are $V_{DD} = 12$ V,
 $I_{DSQ} = 400$ mA (controlled with V_{G1}).

V_{DD} Bias must be applied through a resonant free high inductance on the RF output line.

By-pass capacitor C1 for the auxiliary pad is for a low frequency operation extension (below 1 GHz).

Handling Procedures

Please observe the following precautions to avoid damage:

Static Sensitivity

These electronic devices are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these HBM Class 1A devices.

Recommended PCB Information

RF input and output are 50 Ω transmission lines.
 Single layer 4 mil Rogers RO4350B with 1/2 oz. Cu.
 Use copper filled vias under ground paddle.

Grounding

It is recommended that the total ground (common mode) inductance not exceed 0.03 nH (30 pH). This is equivalent to placing at least four 8-mil (200- μ m) diameter vias under the device, assuming an 8-mil (200- μ m) thick RF layer to ground.

Operating the MAAP-011248

Turn-on

1. Apply V_{G1} (-4.5 V).
2. Increase V_{DD} to 12 V.
3. Set I_{DSQ} by adjusting V_{G1} more positive (typically -3.6 V for $I_{DSQ} = 400$ mA).
4. Apply RF_{IN} signal.

Turn-off

1. Remove RF_{IN} signal.
2. Decrease V_{G1} to -4.5 V.
3. Decrease V_{DD} to 0 V.

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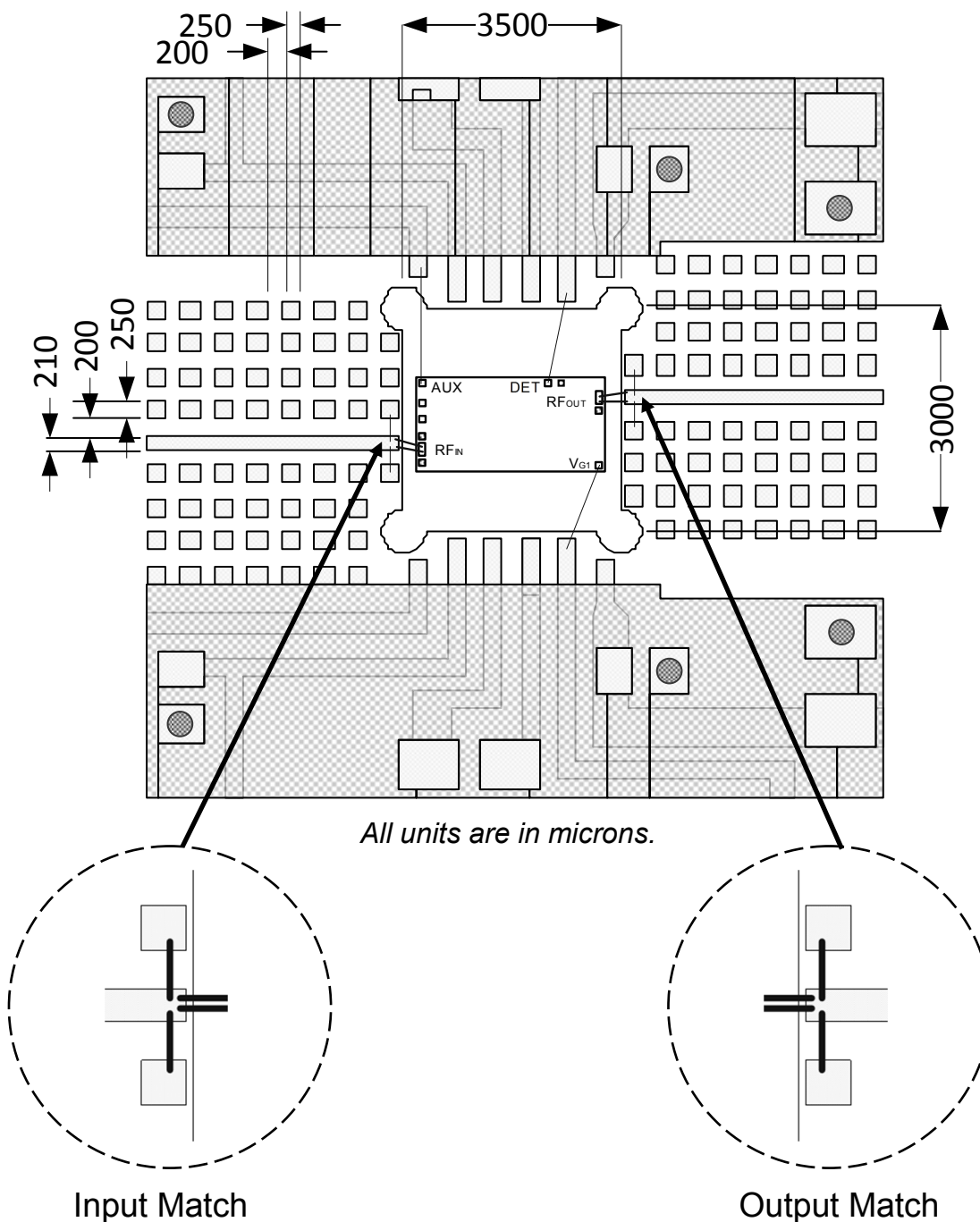


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PCB Layout:

RF input and output port pre-matching circuit patterns are designed to compensate bonding wires. Input and output matching are identical.

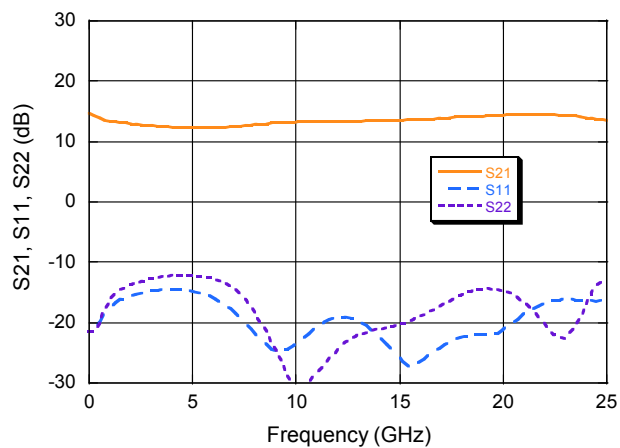
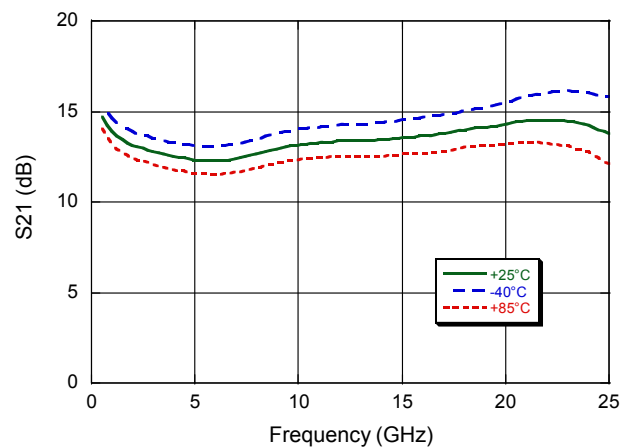
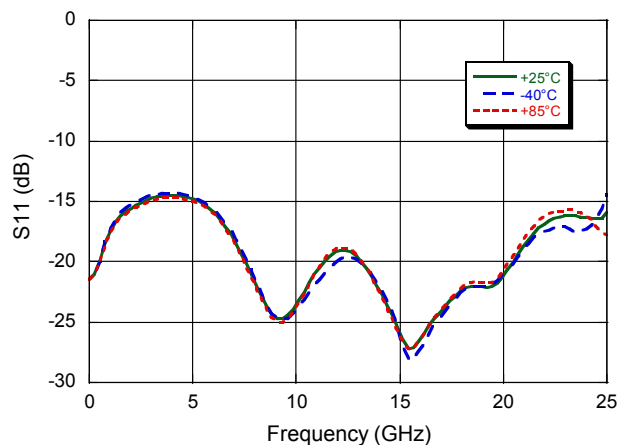
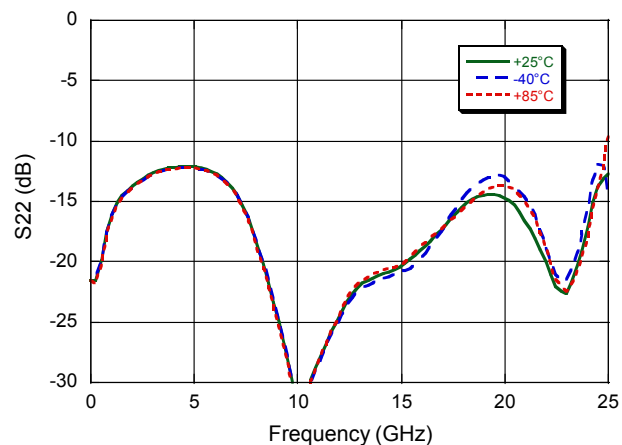
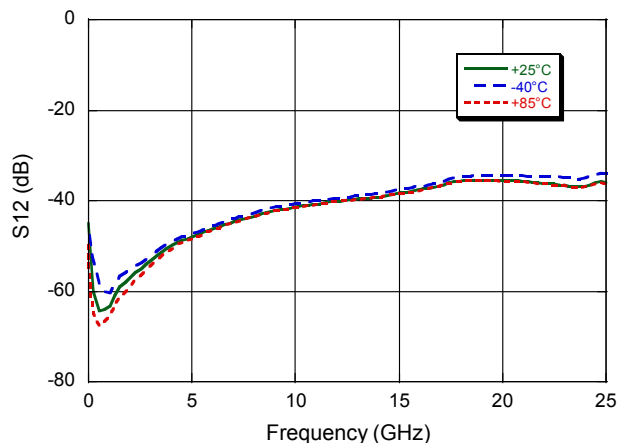
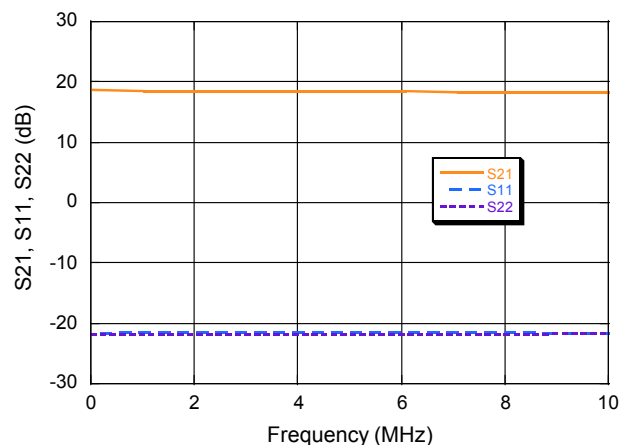


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Typical Performance Curves $V_{DD} = 10\text{ V}$, $I_{DSQ} = 400\text{ mA}$, $V_{G1} = -3.6\text{ V}$ typical**S Parameters****Gain****Input Return Loss****Output Return Loss****Isolation****S Parameters @ Low Frequency**

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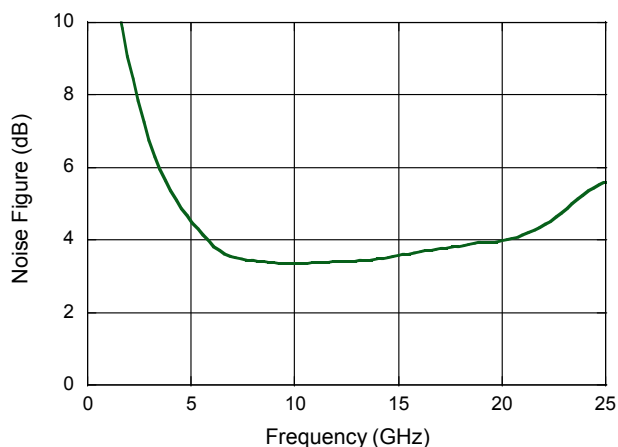
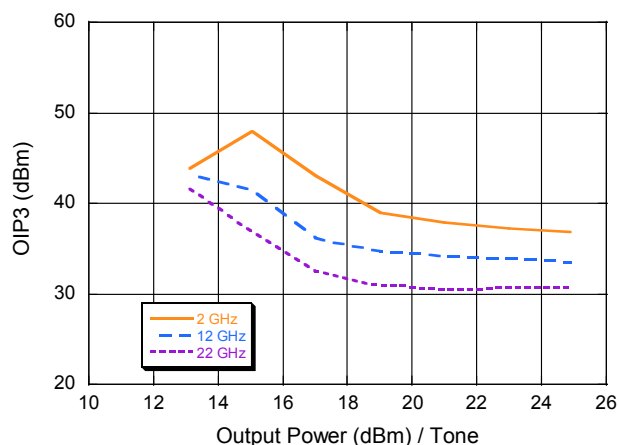


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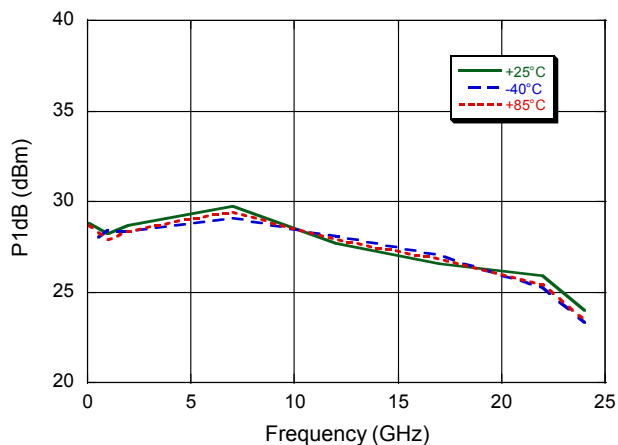
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Typical Performance Curves $V_{DD} = 10\text{ V}$, $I_{DSQ} = 400\text{ mA}$, $V_{G1} = -3.6\text{ V}$ typical

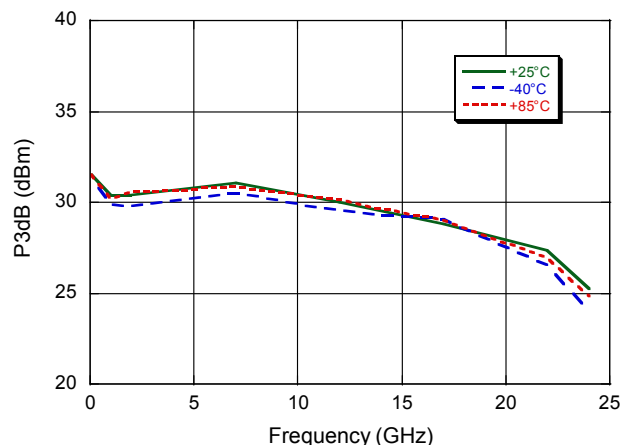
Noise Figure

Output IP3 vs. P_{OUT} / Tone

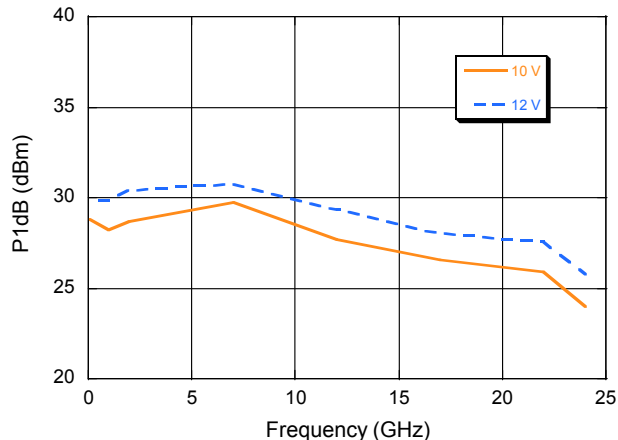
P1dB over Temperature



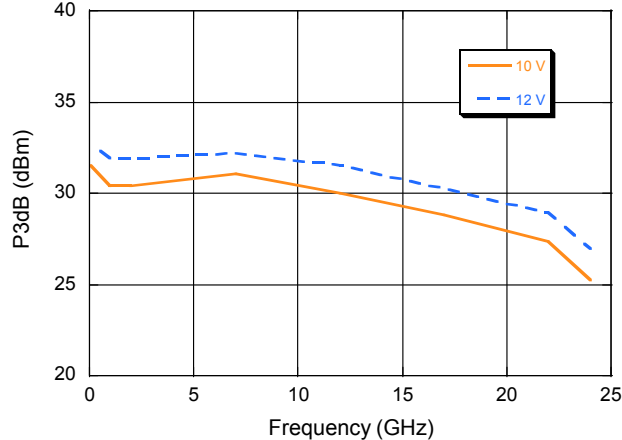
P3dB over Temperature



P1dB over Voltage



P3dB over Voltage

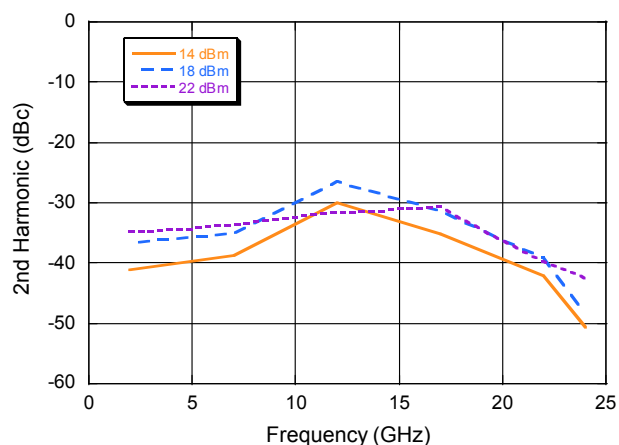
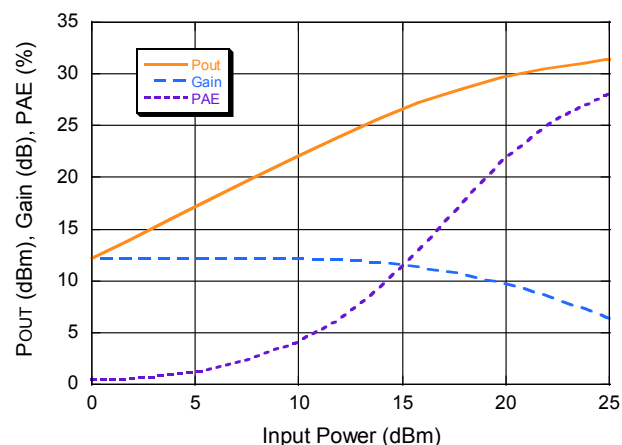
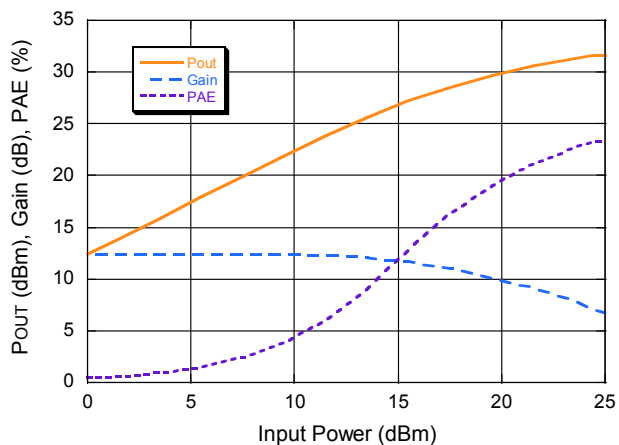
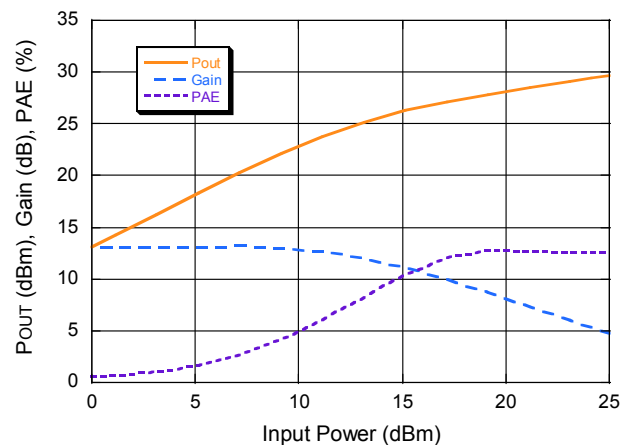
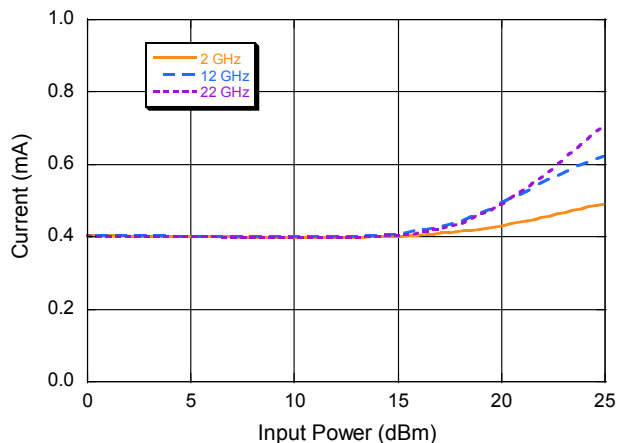


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Typical Performance Curves $V_{DD} = 10\text{ V}$, $I_{DSQ} = 400\text{ mA}$, $V_{G1} = -3.6\text{ V}$ typical**2nd Harmonic****Power Compression @ 2 GHz****Power Compression @ 12 GHz****Power Compression @ 22 GHz****Current**

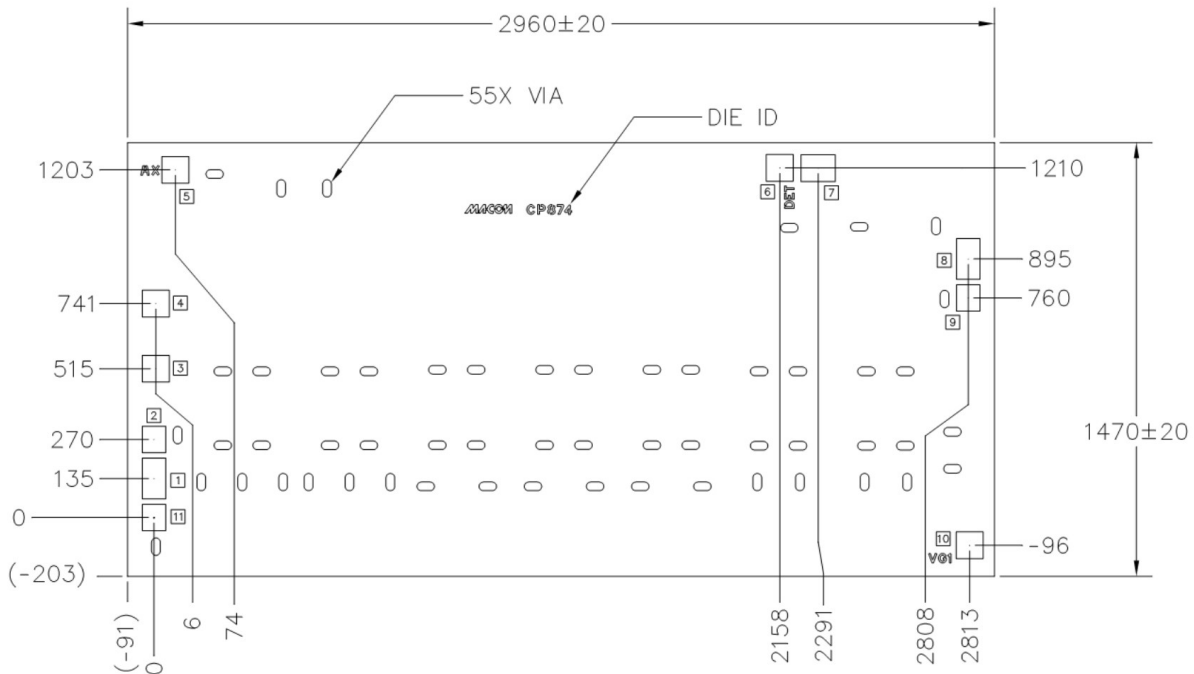
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MMIC Die Outline^{12,13}



12. All units in μm , unless otherwise noted, with a tolerance of $\pm 5 \mu\text{m}$.
 13. Die thickness is $100 \pm 10 \mu\text{m}$.

Bond Pad Detail

Pad	Size (x) (μm)	Size (y) (μm)
1, 8	81	141
2, 9, 11	81	91
3, 4, 5, 6, 10	93	93
7	118	93

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